Calibration of Optical Remote Sensing Data in the Shallow Marine Environment: Defining the Bathymetric, Geologic, and Suspended Sediment Variables

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LONG-TERM GOALS

Our group is investigating the the inner west Florida shelf to determine 1) the distribution of sediments and the associated bathymetry, 2) forcing mechanisms (processes) for particle erosion, vertical particle mixing, and sedimentation, and 3) the effects of these processes on the optical properties of the water column in terms of remote-sensing. These tasks are being performed using innovative sensor and sampling methodologies that provide synergy among the following: optical and acoustical measurements of the distribution of suspended sediment, bottom albedo and microtopography, bathymetry, bottom type, hydrodynamics, and particle dynamics. Measurements of forcing, observed both locally and from as far away as 60 km, will be related to observations of suspended particles and optical properties at two sites in terms of evaluating short-term predictions of erosional potential, suspended sediment distributions, and the effect on the optical properties of the water column. While this provides a broad set of goals for the joint effort, specific goals for each component (e.g. optical, acoustic, hydrodynamic, and particle-dynamic) are addressed in individual proposals.

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OBJECTIVES

Our objectives include the following:

1. Increase the swath bathymetry and side-scan sonar data coverage in the Sarasota, Anna Maria, and Tampa Bay areas to correspond to available AVIRIS data coverage.
2. Continue to document large-scale sediment distribution and movement by producing additional side-scan sonar mosaics in the nearshore Sarasota area within the AVIRIS swath.
3. Increase water column sampling resolution (acoustic and optical measurements, and water samples, vertically, horizontally, and temporally) within the AVIRIS swath and along the Weisberg/Luther mooring transect.
4. Increase the spatial coverage of ground truth data (more cores and analyses) within the AVIRIS swath and along the Weisberg/Luther mooring transect.

APPROACH

In order to aid in the calibration of satellite optical remote sensing data, we are quantifying the geologic template (bottom characteristics, bottom reflectance, bathymetry, sediment resuspension) on the inner continental shelf off west-central Florida (Figure 1)--an area that offers the benefit of previous, ongoing, and additional proposed work beyond ONR efforts (USGS, State of Florida, and NOAA). This project is part of a collaborative effort with other investigators (i.e., Carder and Luther, 1999, and Weisberg and Costello, 1999) and other agencies.

We are approaching this work along two avenues: (1) the geologic product, and (2) the sedimentary process. The geologic products are defined as the bathymetric, textural, and sedimentologic variations on the seabed and the size and type of sediments that may be resuspended. The sedimentary processes are those physical motions that suspend sediments that were originally at rest on the seabed, and advect sediments laterally from other sources. This component also includes a quantification on how the seabed is disturbed and instrument-based measurements of suspended sediment concentrations.

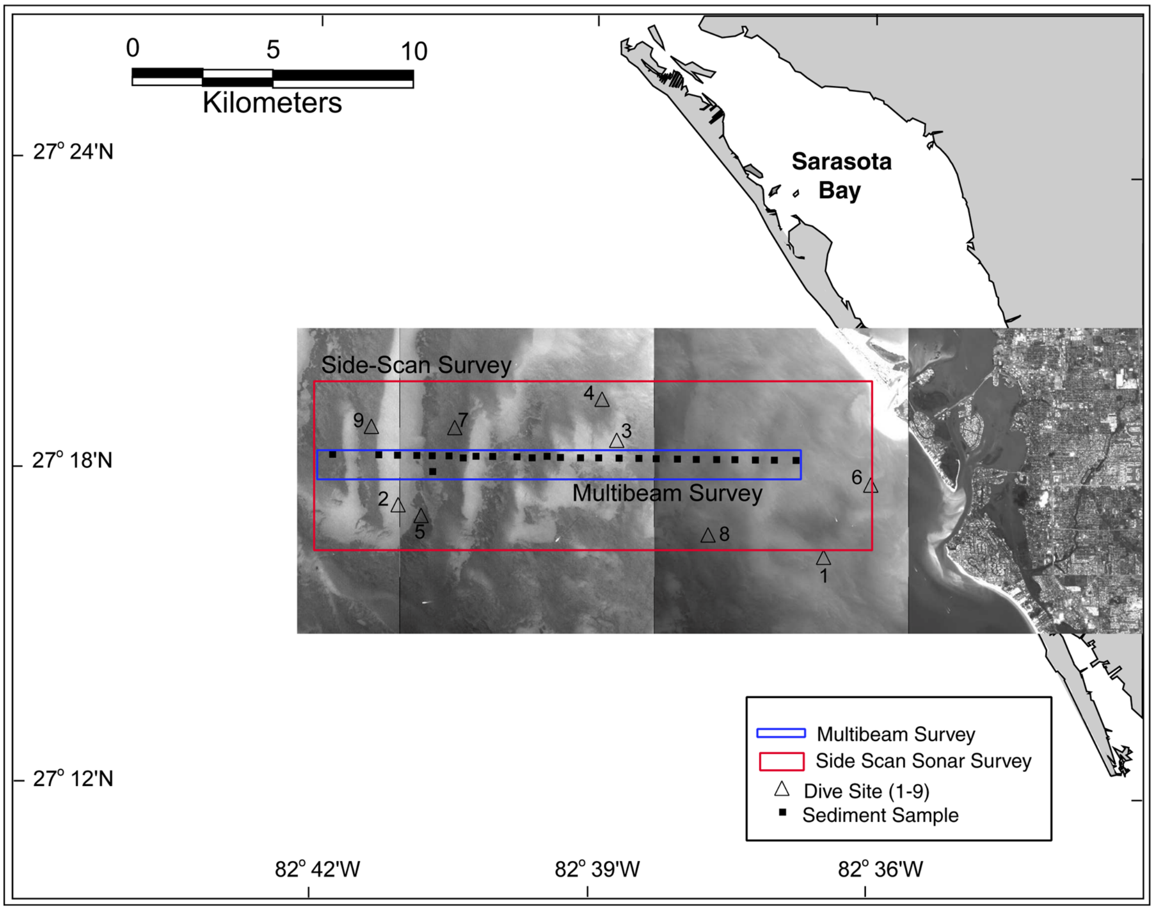
Key players include Dr. Peter Howd (sedimentary processes), Dr. David Naar (multibeam bathymetry operations), Dr. David Mallinson (side-scan sonar operations and sedimentology), and Dr. Albert Hine (acoustic remote sensing interpretation and sedimentary processes).

WORK COMPLETED

During July 5-12, 2000, a cruise supporting the HYCODE project was conducted offshore of Sarasota, Florida aboard the R/V Bellows. The purpose of the cruise was to conduct side-scan sonar and multibeam bathymetry surveys, collect sediment samples, diver observations, and spectral reflectance of the sea surface and seafloor. The study area is located offshore Sarasota, from Big Sarasota Pass to north of New Pass (Figure 1). This area was chosen to correspond to existing AVIRIS (Airborne Visible/Infrared Imaging Spectrometer) data and Ocean PHILLS (Ocean Portable Hyperspectral imager for Low-Light Spectroscopy) data acquired by airborne platform during the cruise.

AVIRIS data and the locations of data collected aboard the R/V Bellows are shown in Figure 1. The side-scan sonar data (acoustic backscatter) was acquired at 100 kHz using an EG&G Model 272 TD

towfish. The survey provided 100% coverage over a 125 km^2 area that started 3 km offshore of Big Sarasota pass and extended 20 km across the shelf (Figure 2). Water depths ranged from approximately 4 m to 15 m. High-resolution multibeam bathymetry data were collected concurrently using the Simrad EM3000 system. The multibeam survey provided 100% coverage over an area of 20 km^2 that extended from 27°16.6' N to 27°18.5' N and 82°38' W to 82°48'W. Sediment grab samples were collected for ground truth purposes along a transect running EW through the study area (Figure 1). Nine dives were made at locations that represent different bottom types and depth regimes within the study area (Figure 1). At each dive site, sediment samples, digital video images, and still photographs were collected for analysis at USF. Spectral reflectance of the seafloor was measured using the DiveSpec, a diver-operated instrument. Two instruments were used at dive sites 3, 8, and 9.

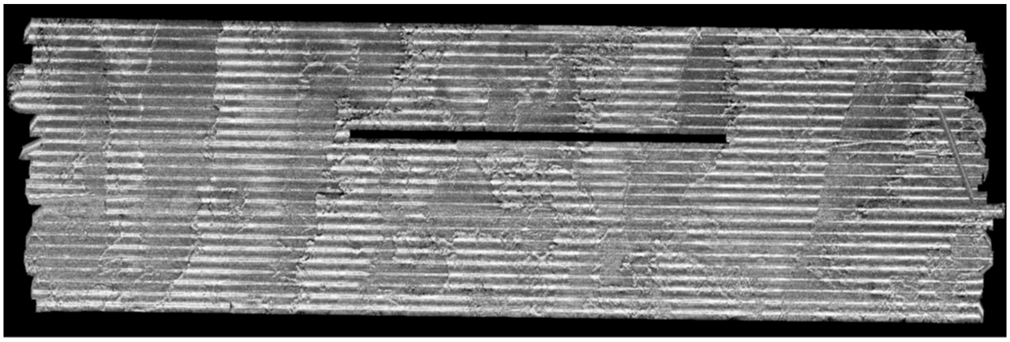


1. AVIRIS data and the locations of the side-scan sonar survey, multibeam bathymetry survey, sediment samples and dive sites investigated using the R/V Bellows, July 5-12, 2000.

Twenty sea-surface remote sensing reflectance (Rrs) measurements were also taken to correspond with sites where bottom samples and bottom reflectance data were collected.. Since location and time are noted for any Rrs measurements, sea-surface Rrs can be compared to over-flight information for verification of upwelling radiance patterns seen in the aircraft imagery.

In addition to the Rrs information, an on-deck inherent optical property sampler (SoDOPF) was in use during most of the cruise. Sampling several times a minute, it collected over 120 hours of optical and CTD data from the near-surface water. The SoDOPF configuration during July of 2000 included a FSI

CTD, WETLabs transmissometers at 480, 532, and 660 nm, Seatech (WETLabs) chlorophyll and CDOM fluorometers, a light scatter (860nm) sensor, and a HOBILabs HS-2 backscatter (470 & 676nm) sensor.



2. 100 kHz side-scan sonar mosaic of the area outlined in red in Figure 1. Dark gray areas represent low acoustic backscatter and correspond to well sorted fine to medium quartz sands, and high optical reflectance. Lighter shades of gray represent high acoustic backscatter, and correspond to coarse sand and gravel and hardbottom areas, and low optical reflectance.

RESULTS

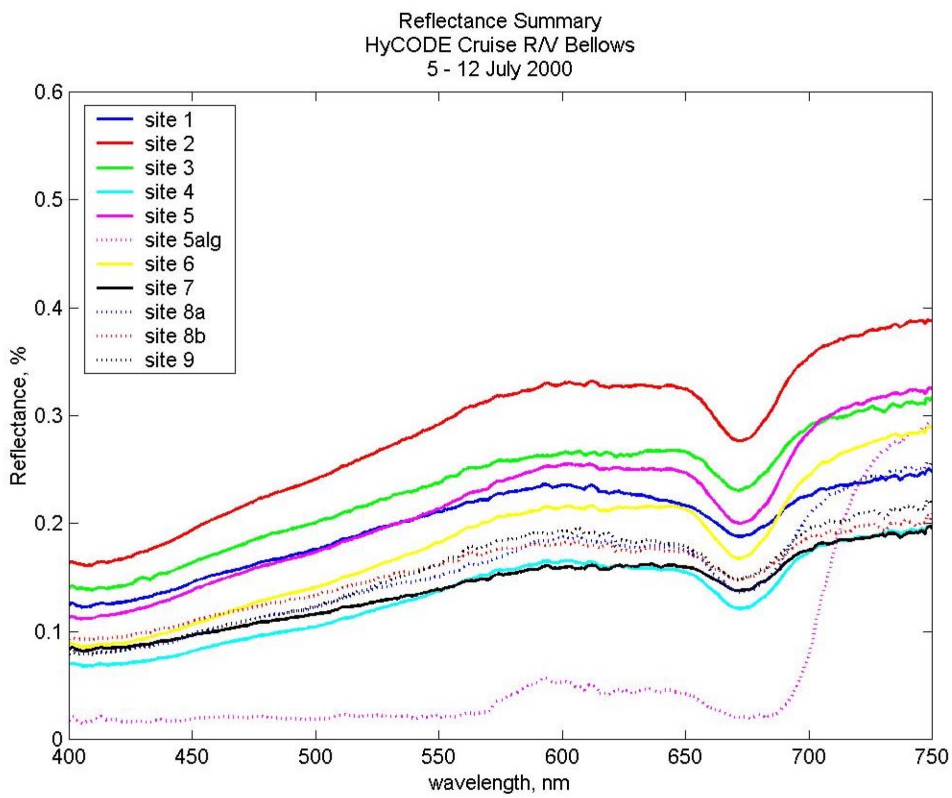
Bottom samples and diver observations reveal the geologic character of the seafloor within the study area. Three main facies were found including 1) hardbottom (with live-bottom communities), 2) moderately sorted, fine to medium quartz sands, and 3) poorly sorted, coarse bioclastic/lithoclastic sand and gravel. Acoustic backscatter data provided by the side-scan sonar survey can be used to define the distribution of the different bottom types. Acoustic backscatter imagery correspond well with the AVIRIS data in the middle to outer study area implying a close correspondance between seafloor character and optical reflectance. AVIRIS data in the inner study area show poorer correspondance with the acoustic facies indicating greater water column effects.

There is a reasonable correspondence between the measured in situ seafloor reflectances and the qualitative view provided by the AVIRIS image. Site 2 appears bright in the image and proved to be a (relatively) high reflectance sand (Figures 1 and 2). Sites 7 and 9 were characterized by very dark sands. Site 5, which appears very dark in the image, was a low relief hardground environment hosting a community of algae and small hard and soft corals. Sediment patches, which show a moderately high reflectance, constituted on the order of 5% of the bottom cover. The bottom was dominated by clumps of a stalked red macroalga with low reflectance.

At site 7 measurements were made both of the undisturbed sediment surface and of the sediment comprising a bioturbation mound. The former material was a brown-gray, while the latter material appeared gray, presumably having passed through the gut of some burrowing organism, where the benthic microalgae were removed. The ‘cleaned’ sediment is characterized by increased reflectance in the blue and around 670 nm, portions of the spectrum at which chlorophyll absorption is strong, and decreased reflectance above 700 nm, where chlorophyll ordinarily enhances reflectance. Similar results were noted at Site 4 where measurements were made on unbioturbated sand and sands that were grazed by echinoids.

IMPACT/APPLICATIONS

The concurrence of side-scan data (providing distribution of bottom types which can be related to optical reflectance), seafloor reflectance data, bathymetric data, and sea-surface reflectance data will provide the ground truth data necessary to derive water column optical properties or bathymetry from the PHILLS data, and to test existing models. Bathymetric data will be used to correct for the water depth in optical remote sensing calibrations, and to provide the template upon which physical oceanographic processes will be modeled, and sediment resuspension and transport can be evaluated. These data will be made available to other HyCODE investigators upon request.



3. Summary of seafloor reflectance data.

TRANSITIONS

These data are being used by EcoHab/HyCODE investigators to aid in computer modeling of shelf circulation patterns, and to evaluate optical remote sensing data (Weisberg and Luther, 1999; and Carder and Costello, 1999).

RELATED PROJECTS

Weisberg and Luther (1999) are modeling circulation on the West Florida Shelf and will utilize our bathymetric data.

Carder and Costello (1999) are measuring optical properties of coastal waters and will be utilizing our bathymetric and sedimentologic data.

REFERENCES

Carder, K., and D. Costello, 1999, An investigation of the optical properties of coastal waters using unmanned underwater vehicles, a network of moored sensor packages and remote sensing data: A Research Proposal Submitted to the Office of Naval Research in response to BAA 99-021.

Weisberg, R., and M. Luther, 1999, Observations and modeling of west Florida continental shelf circulation: A Research Proposal Submitted to the Office of Naval Research in response to BAA 99-021.